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FINAL REPORT
FOR
JANTX 1N3893

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Prepared
For

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Marshall Space Flight Center, Alabama 35812

DCA RELIABILITY LABORATORY
SPECIAL PRODUCTS DIVISION
975 BENICIA AVE
SUNNYVALE, CALIFORNIA 94086





FOREWORD

This report is a summary of the work performed on NASA Contract NAS8-31944. The investigation was conducted for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama. The Contracting Officer's Technical Representative was Mr. F. Villella.

The short-term objective of this preliminary study of transistors, diodes, and FETS is to evaluate the reliability of these discrete devices, from different manufacturers, when subjected to power and temperature step stress tests.

The long-term objective is to gain more knowledge of accelerated stress testing for use in future testing of discrete devices, as well as to determine which type of stress should be applied to a particular device or design.

This report is divided as follows: description of tests, figures, tables, and appendix.

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1.0 INTRODUCTION

DCA Reliability Laboratory, under Contract NAS8-31944 for NASA/Marshall Space Flight Center, has compiled data for the purpose of evaluating the effect of power/temperature step stress when applied to a variety of semiconductor devices. This report covers the diode JANTX1N3893 manufactured by SIEMENS and MOTOROLA.

A total of 48 samples from each manufacturer were submitted to the process outlined in Table 1. In addition, two control sample units were maintained for verification of the electrical parametric testing

2.0 TEST REQUIREMENTS

2.1 Electrical

All test samples were subjected to the electrical tests outlined in Table 2 after completing the prior power/temperature step stress point. These tests were performed using the Fairchild Model 600 High-Speed Computer-Controlled Tester. Additional bench testing was also required on the devices.

2.2 Stress Circuit

The test circuit shown in Figure 1 was used to power all the test devices during the power/temperature stress conditions. The voltage was set by V_F and the current was varied in order to comply with the specified power rating for the device. At least one of the devices was subjected to maximum rated power (MRP). All remaining devices were



subjected to no less than 90% of MRP. See Figure 1 for load resistance values and voltages.

2.3 Group I - Power Stress

Thirty-two units, 16 from each manufacturer, were submitted to the Power Stress Process. The diodes were stressed in 500-hour steps at 50, 100, 125, 150 and 175 percent of maximum rated power (MRP) for 2500 hours or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each power step. See Table 1. (*See Notes at end of text.)

2.4 Group II - Temperature Stress I

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress I Process. Group II was subjected to 1600 hours of stress at maximum rated power in increments of 160 hours. The temperature was increased in steps of 25°C, commencing at 75°C and terminating at 300°C or until 50% or more of the devices failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

2.5 Group III - Temperature Stress II

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress II Process. Group III was subjected to 112 hours of stress at maximum rated power in increments of 16 hours. The temperature was increased in steps of 25°C, commencing at 150°C and terminating at 300°C or until 50% or more of the devices in a sample lot



failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

3.0 DISCUSSION OF TEST RESULTS

3.1 Group I - Power Stress

3.1.1 Siemens. The Siemens sample lot completed 1650 hours of Group I Testing at which point 50% of the lot failed. The lot continued processing another 360 hours and suffered one additional failure. The first two failures occurred 150 hours into the 150% MRP step. Serial numbers 202 and 206 failed due to excessive I_R leakage. The next failure occurred 50 hours into the 125% MRP step. Serial number 200 failed due to excessive I_R leakage. The next failures occurred 500 hours into the 125% MRP step. Serial numbers 207 and 209 failed the maximum V_F limit. Serial number 199 was removed from the testing as a visual catastrophic failure because the anode lead detached due to the stress. The next failure occurred 10 hours into the 150% MRP step. Serial number 213 failed the maximum V_F limit. The next failure occurred 150 hours into the 150% MRP step. Serial number 212 failed the maximum V_F limit. The last failure occurred 10 hours into 175% MRP step. Serial number 210 failed the maximum V_F limit. Typical characteristics of this lot's performance were:

- 1) The mean value for I_R changed 29.06 μA from an initial mean of 3.061 μA to a final mean of 32.12 μA .
- 2) The mean value for V_F changed 62.00mV



from an initial mean of 1.356V to a final mean of 1.418V.

The control units for this lot remained constant throughout the entire Group I Testing.

3.1.2 Motorola. The Motorola sample lot completed 1750 hours of Group I Testing before the lot was stopped because more than 50% of the devices failed. The first failure occurred 150 hours into the 100% MRP step. Serial number 253 failed due to excessive I_R leakage. The next failures occurred 25 hours into the 125% MRP step. Serial numbers 254 and 258 were removed from testing as visual catastrophic failures because the cathode stud connection detached due to the stress. The next failure occurred 250 hours into the 125% MRP step. Serial number 263 was removed from testing because the cathode stud connection detached. The next failure occurred 500 hours into the 125% MRP step. Serial number 256 was removed from testing because the cathode stud connection detached. The next failure occurred 25 hours into the 150% MRP step. Serial number 259 was removed from testing because the cathode stud connection detached. The final failures occurred 250 hours into the 150% MRP step. Serial numbers 261, 262, and 268 were removed from testing as visual catastrophic failures because the cathode stud connections detached due to the stress. Typical characteristics of this lot's performance were:

- 1) The mean value for I_R changed 1.306 μ A from an initial mean of 1.952 μ A to a final mean of 3.258 μ A.
- 2) The mean value for V_F changed 99.00mV

from an initial mean of 1.234V to a final mean of 1.333V.

The control units for this lot remained constant throughout the entire Group I Testing.

3.1.3 Statistical Summary - Group I. Table 4 outlines the results of Group I - Power Stress for the two electrical parameters and all measurement points for both Siemens and Motorola.

3.2 Group II - Temperature Stress

3.2.1 Siemens. The Siemens sample lot completed a total of 1120 hours of Group II testing before the lot was stopped because the failure rate exceeded 50% of the lot. The first failure occurred 160 hours into the 100°C-temperature step. Serial number 223 failed due to excessive I_R leakage. The next failures occurred 160 hours into the 175°C-temperature step. Serial numbers 217 and 222 were removed from the testing as visual catastrophic failures because the anode lead detached due to stress. The next failures occurred 160 hours into the 200°C-temperature step. Serial numbers 224 and 226 were removed from testing because the anode leads became detached. The final failures occurred 160 hours into the 225°C-temperature step. Serial numbers 216, 218, 219, 220, 221, 228 and 230 were removed from testing as visual catastrophic failures because the anode leads detached due to the stress. Typical characteristics of this lot's performance were:

- 1) The mean value for I_R changed 3.553μA from an initial mean of 2.581μA to a final



mean of 6.134 μ A.

- 2) The mean value for V_F changed 37.00mV from an initial mean of 1.353V to a final mean of 1.390V.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.2 Motorola. The Motorola sample lot completed a total of 640 hours of Group II Testing before the lot was stopped due to a failure rate of more than 50% of the lot. The first failures occurred 160 hours into the 75°C-temperature step. Serial numbers 274 and 284 failed because of excessive I_R leakage. One device was pulled from testing 160 hours into the 125°C-temperature step. Serial number 272 was removed at this point as a MIL-S-19500 failure. The final failures occurred 160 hours into the 150°C-temperature step. Serial numbers 275, 277, 278, 280, 281, 282 and 283 were removed from testing as visual catastrophic rejects because the cathode stud connection detached due to stress. Typical characteristics of this lot's performance were:

- 1)) The mean value for I_R changed 22.07 μ A from an initial mean of 1.822 μ A to a final mean of 23.89 μ A.
- 2) The mean value for V_F changed 41.00mV from an initial mean of 1.209V to a final mean of 1.250V.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.3 Statistical Summary - Group II. Table 5 of this report outlines the results of Group II -



Temperature Stress I Testing for the two electrical parameters and all of the measurement points for both Siemens and Motorola.

3.3 Group III - Temperature Stress II

3.3.1 Siemens. The Siemens sample lot completed the entire 112-hour Group II Testing with only one catastrophic failure. One device was pulled from testing 16 hours into the 275°C-temperature step. Serial number 241 was removed as a MIL-S-19500 failure. The catastrophic failure occurred 16 hours into the 300°C-temperature step. Serial number 246 was considered a visual failure because the anode lead detached due to the stress. Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed 3.996 μ A from an initial mean of 2.602 μ A to a final mean of 6.598 μ A.
- 2) The mean value for V_F changed 100.0mV from an initial mean of 1.330V to a final mean of 1.430V.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.2 Motorola. The Motorola sample lot completed 16 hours of the Group III Testing before the lot was stopped because of a failure rate of 50% of the devices. Eight failures occurred 16 hours into the 150°C temperature step. Serial numbers 291 and 294 were removed from testing as visual catastrophic failures because the anode lead



anode lead detached due to the stress. Serial numbers 285, 289, 293, 295, 297 and 298 were removed as visual catastrophic failures because the cathode stud connection detached due to the stress. Typical characteristics of this sample lot's performance were:

- 1) The average mean for I_R changed 627.9 μA from an initial mean of 56.50 μA to a final mean of 684.4 μA .
- 2) The average mean for V_F changed 13.00mV from an initial mean of 1.246V to a final mean of 1.259V.

The control units for this sample unit remained constant throughout the entire Group III Testing.

3.3.3 Statistical Summary - Group III. Table 6 outlines the results of Group III Testing for the two electrical parameters and all measurement points for both Siemens and Motorola.

4.0 FINAL DATA SUMMARY

Table 7 statistically summarizes the change in the mean value from the zero-hour data to the final data. The graphs of Figures 2 and 4 plot the cumulative percent failures versus the temperature stress level for Group II - Temperature Stress I, and Group III - Temperature Stress II. The graphs of Figures 3 and 5 plot the time step for Group I (160 hours) and Group III (16 hours) versus the temperatures T_1 and T_2 calculated from Figures 2 and 4. Tables 8 and 9 summarize the failures encountered for all three stress groups. The failures are separated into two categories:



catastrophic failures in Table 8 and parametric failures in Table 9. The data from Table 8 were used as a source for the graphs in Figures 2 and 4. Figures 2 and 4 were used as a source for the graphs in 3 and 5, respectively. Junction temperature is plotted on an inverse hyperbolic scale.

5.0

CONCLUSIONS

After studying the test results, it appears that the Siemens diode is sturdier than the Motorola diode. The Motorola lots had to be stopped in all three testings, whereas the Siemens lot endured 25 more hours of Group I and 480 more hours of Group II Testing before being stopped. Furthermore, the Siemens lot completed the entire Group III Testing with only one catastrophic failure.

Because of an apparent failure mode, failure analysis was performed only on the Group II Testing. The majority of the devices were visual catastrophic failures due to the stress. Most of the Siemens failures were caused by the anode lead detaching due to the stress. In the Motorola lot, the cup-to-stud detached and the device came apart. Failure analysis also revealed a loss of the glass seal tubulation and wire lead on the Siemens devices.

A plot showing the cumulative failure distribution for Groups II and III was drawn for the Siemens' sample lot (Figures 2 and 3), but a plot for the Motorola sample lot could not be drawn due to an



insufficient number of failure points in the Groups II and III Testing (Figures 4 and 5). Figures 2 and 3 display the data for the Siemens sample lot used to calculate an activation energy of .75eV.

A broken circle around a marked point on the graph indicates a freak failure not calculated as part of the regression line. A solid circle around a marked point indicates an isolated main failure point. The regression line was calculated using the least squares method.

The activation energy was calculated from the formula:

$$E = \left[\ln \left(\frac{t_1}{t_2} \right) \right] \left[\frac{8.63 \times 10^{-5} \text{ eV/}^\circ\text{K}}{\left(\frac{1}{T_1 + 273} \right) - \left(\frac{1}{T_2 + 273} \right)} \right] \text{ eV}$$

Where: t_1 = step of Group II - Temp Stress I = 160 hrs.

t_2 = step of Group III - Temp Stress II = 16 hrs.

T_1 = temperature in $^\circ\text{C}$ of 16% failure for Group II.

T_2 = temperature in $^\circ\text{C}$ of 16% failure for Group III.



JANTX1N3893

NOTE:

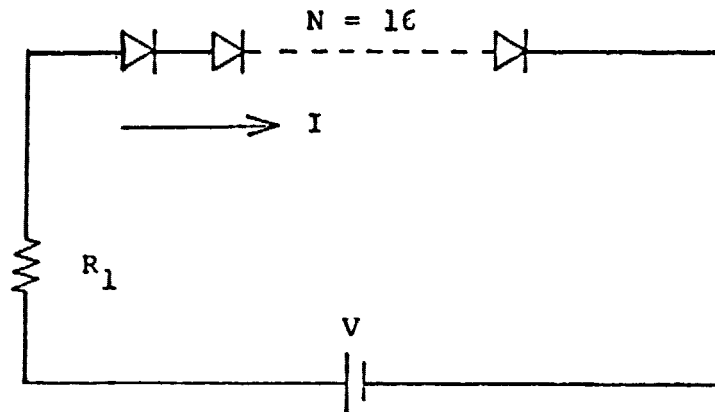
*** Conditions for failure:**

- A) Open or short
- B) Leakage exceeds the maximum limit by 100 times.
- C) Other parameters exceed MIL limits by 50% or more.



JANTX1N3893

SWITCHING DIODES



$$R_1 = 1V/I \pm 1\%$$

$$P_d = IE$$

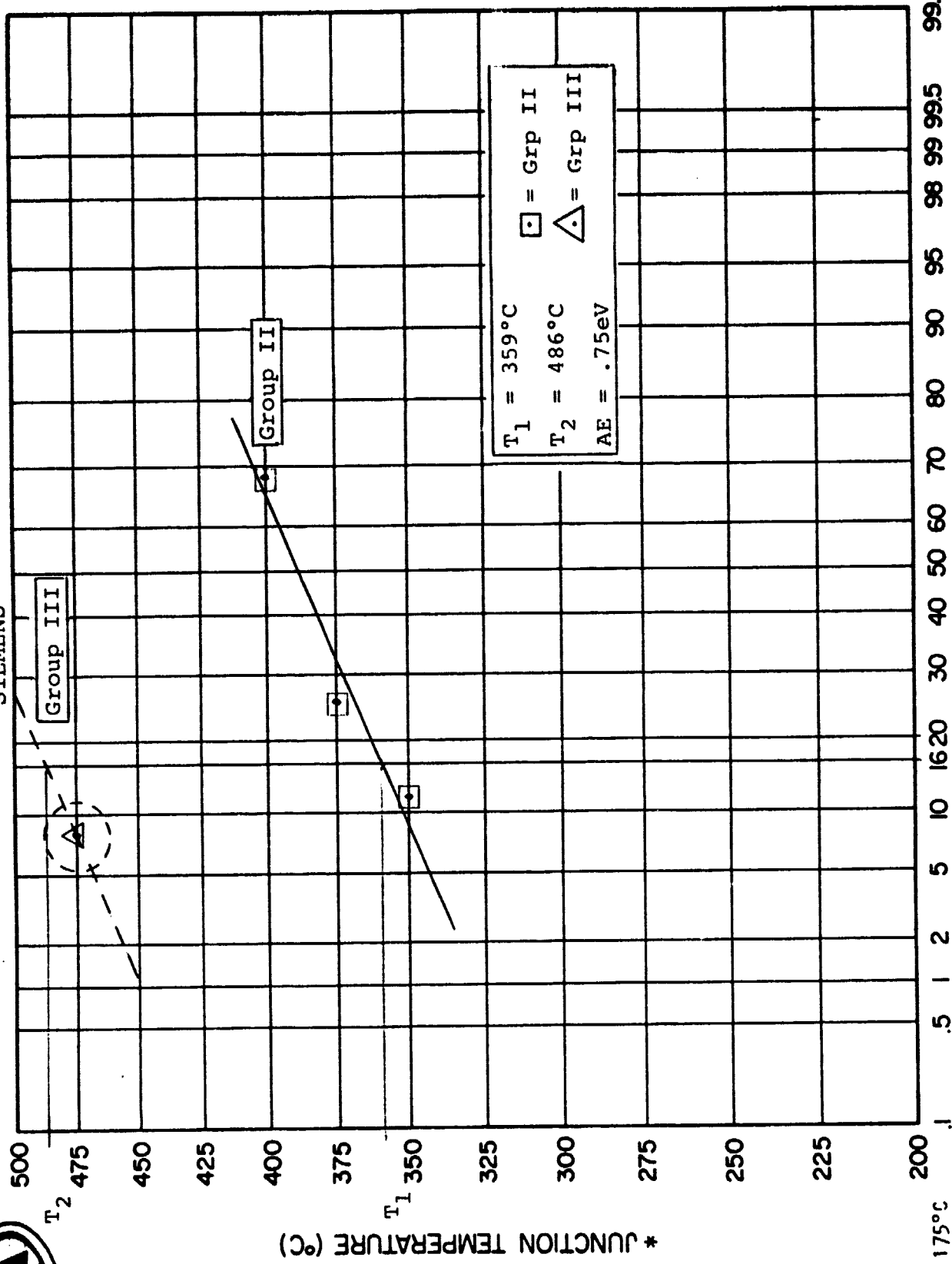
FIGURE 1
Power/Temperature Stress Circuit
for JANTX1N3893

SIEMENS

Group III

Group II

$T_1 = 359^{\circ}\text{C}$
 $T_2 = 486^{\circ}\text{C}$
 $AE = .75\text{eV}$



*NOTE

$T_J \approx T_A + 175^{\circ}\text{C}$

FIGURE 2
Cumulative Percent Failures Versus Junction Temperature, Siemens

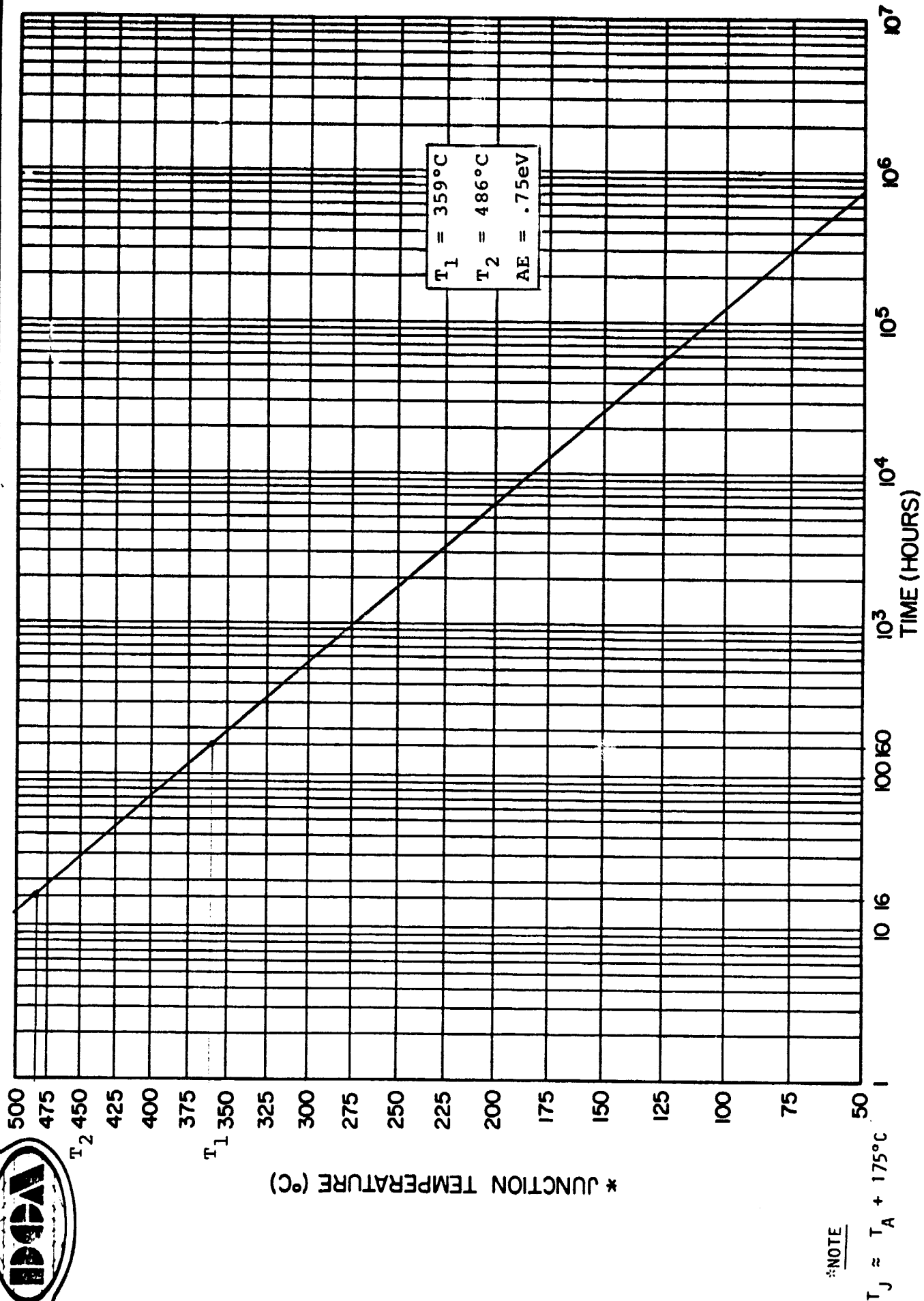


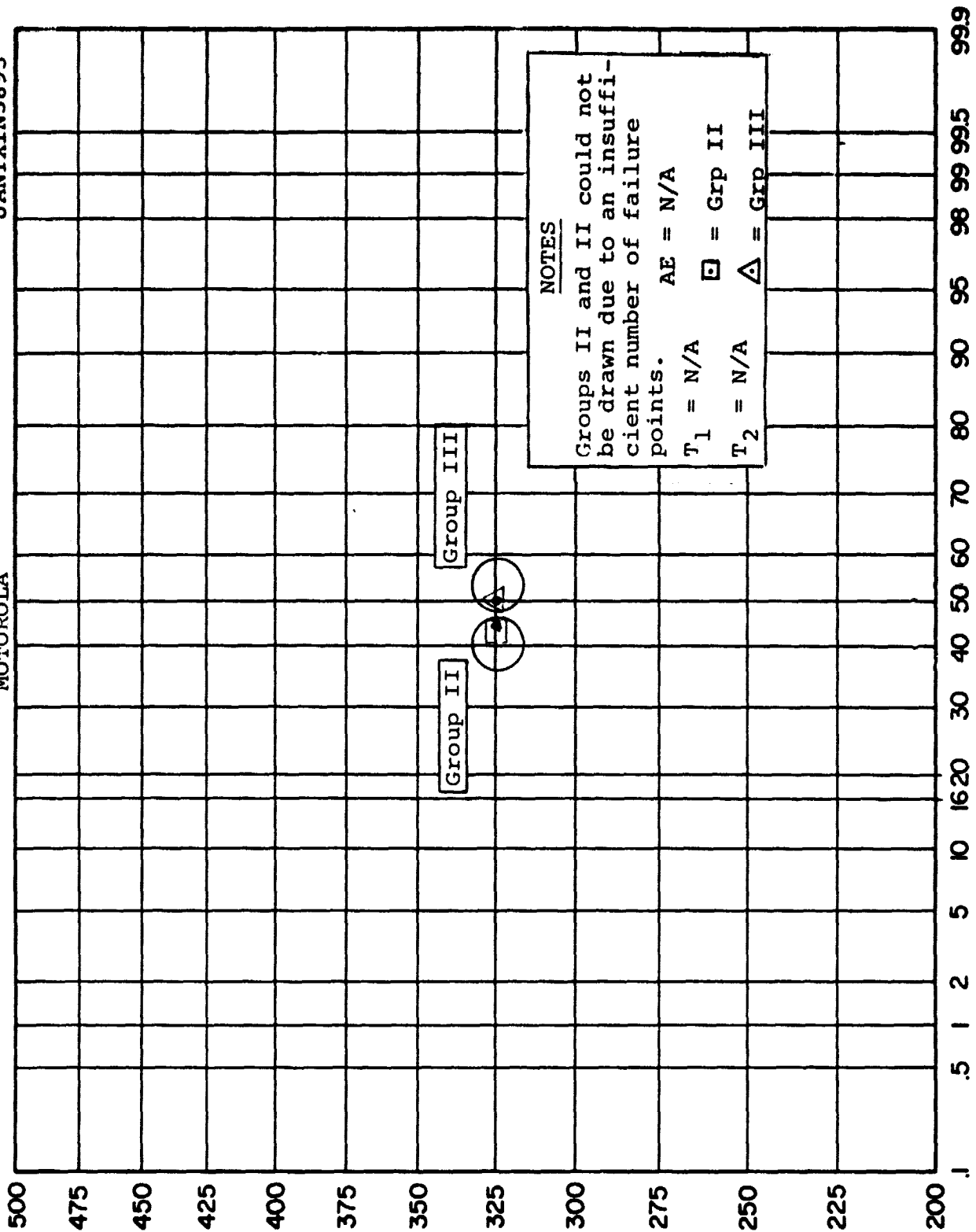
FIGURE 3
 Time Steps Versus Junction Temperature, Siemens



MOTOROLA

JANTX1N3893

JANTX1N3893

**NOTES**

Groups II and III could not be drawn due to an insufficient number of failure points.

$T_1 = N/A$ $AE = N/A$

$T_2 = N/A$ $\square = \text{Grp II}$

$\Delta = \text{Grp III}$

***NOTE**

$$T_J \approx T_A + 175^\circ\text{C}$$

CUMULATIVE PERCENT FAILURES (%)**FIGURE 4**

Cumulative Percent Failures Versus Junction Temperature, Motorola

* JUNCTION TEMPERATURE (°C)

*NOTE

$$T_J = T_A + 175^\circ\text{C}$$

NOTES

Graph could not be plotted
due to the insufficient
number of failure points.

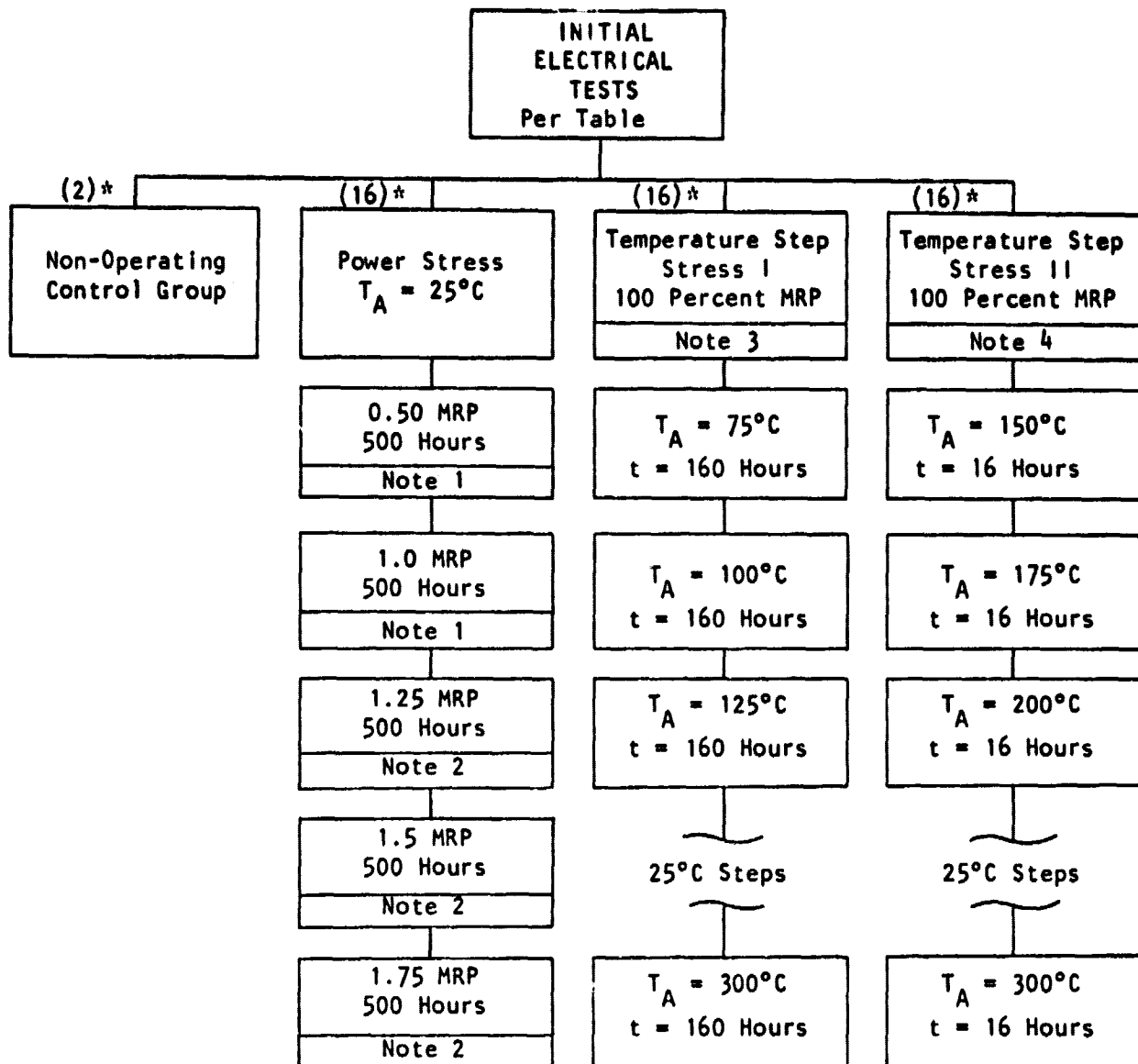
$$T_1 = N/A$$

$$AE = N/A$$

$$T_2 = N/A$$

TIME (HOURS)
FIGURE 5

Time Steps Versus Junction Temperature, Motorola

TABLE 1
TEST FLOW DIAGRAM

*Quantity per manufacturer (Siemens and Motorola)

NOTES:

- 1) Electrical measurements per Table 2 were made at 50, 150, 250 and 500 hours.
- 2) Electrical measurements per Table 2 were made at 10, 25, 50, 150, 250 and 500 hours.
- 3) Electrical measurements per Table 2 were made at the end of each 160 hours.
- 4) Electrical measurements per Table 2 were made at the end of each 16 hours.



JANTX1N3893

TABLE 2
PARAMETERS AND TEST CONDITIONS

PARAMETER	CONDITIONS	SPEC. LIMIT		CAT. LIMIT		UNITS
		MIN	MAX	MIN	MAX	
I_R	@ $V_R = 400V$	-	15	-	1500	μA
V_F	@ $I_F = 38A(PK)$	-	1.5	-	2.25	V(PK)

NOTES:

1/ In addition, any open or short shall be considered catastrophic.

TABLE 3
POWER STRESS BURN-IN CONDITIONS

$V_F = 1V$	
I_F	Percent P_D
3.0A	50
6.0A	100
7.5A	125
9.0A	150
10.5A	175



NOTE
FOR TABLES
4 THROUGH 7

The minimum/maximum initial and final data generally have an absolute accuracy of $\pm 1\%$ of the reading and \pm one digit except for readings greater than 9.99mA which have an absolute accuracy of $\pm 2\%$ of the reading and \pm one digit. The data also have a resolution for four digits. The standard deviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.



TABLE 4
GROUP I - POWER STRESS DATA SUMMARY

Page 1 of 2

PARAMETER	$I_R = 15\mu A(\text{MAX})$		$V_F = 1.5V(\text{PK}) (\text{MAX})$		
CONDITIONS AND LIMIT	$V_R = 400V$		$I_F = 38A(\text{PK})$		
IDENTIFICATION	SIE	MOT	SIE	MOT	
INITIAL DATA					
MIN VALUE	1.470 μA	1.020 μA	1.210V	1.080V	
MAX VALUE	8.980 μA	5.510 μA	1.440V	1.390V	
MEAN	3.061 μA	1.952 μA	1.356V	1.234V	
STD DEV	2.160 μA	1.137 μA	62.24mV	71.93mV	
INTERIM DATA					
POWER 50 TO 125% Δ MEAN VALUE					
50% POWER					
50 HRS	3.405 μA	2.528 μA	0.000V	12.00mV	
150 HRS	3.818 μA	3.271 μA	8.000mV	15.00mV	
250 HRS	3.057 μA	2.381 μA	14.00mV	17.00mV	
500 HRS	3.040 μA	1.329 μA	3.000mV	47.00mV	
100% POWER					
550 HRS	4.438 μA	41.08 μA	12.00mV	54.00mV	
650 HRS	395.8 μA	*678.7 μA	17.00mV	63.00mV	
750 HRS	183.4 μA	627.7 μA	22.00mV	68.00mV	
1000 HRS	44.88 μA	23.42 μA	14.00mV	31.00mV	
125% POWER					
1010 HRS	21.23 μA	2.127 μA	35.00mV	26.00mV	
1025 HRS	1.318mA	7.201 μA	32.00mV	34.00mV	
1050 HRS	*731.4 μA	25.69 μA	30.00mV	31.00mV	
1150 HRS	31.15 μA	30.68 μA	27.00mV	29.00mV	
1250 HRS	19.29 μA	13.96 μA	34.00mV	27.00mV	
1500 HRS	20.61 μA	3.460 μA	25.00mV	17.00mV	

(continued on second sheet)



PARAMETER	$I_R = 15\mu A(MAX)$		$V_F = 1.5V(PK) (MAX)$		
CONDITIONS AND LIMITS	@ $V_R = 400V$		@ $I_F = 38A(PK)$		
IDENTIFICATION	SIE	MOT	SIE	MOT	
INITIAL DATA					
MIN VALUE	1.470 μA	1.020 μA	1.210V	1.080V	
MAX VALUE	8.980 μA	5.510 μA	1.440V	1.390V	
MEAN	3.061 μA	1.952 μA	1.356V	1.234V	
STD DEV	2.160 μA	1.137 μA	62.24mV	71.93mV	
INTERIM DATA					
POWER 150 TO 175% Δ MEAN VALUE					
150% POWER					
1510 HRS	23.39 μA	5.253 μA	17.00mV	40.00mV	
1525 HRS	41.95 μA	5.747 μA	13.00mV	36.00mV	
1550 HRS	25.48 μA	12.73 μA	15.00mV	36.00mV	
1650 HRS	27.73 μA	19.71 μA	22.00mV	37.00mV	
1750 HRS	6.500 μA	1.306 μA	21.00mV	99.00mV	
2000 HRS	13.47 μA	JOB STOPPED	60.00mV	JOB STOPPED	
175% POWER					
2010 HRS	29.06 μA		62.00mV		
2025 HRS	JOB STOPPED		JOB STOPPED		
2050 HRS					
2150 HRS					
2250 HRS					
2500 HRS					
FINAL DATA					
MIN VALUE	778.0nA	998.0nA	1.240V	1.210V	
MAX VALUE	90.00 μA	12.80 μA	1.500V	1.480V	
MEAN	32.12 μA	3.258 μA	1.418V	1.333V	
STD DEV	30.50 μA	3.926 μA	82.73mV	100.5mV	

* NOTE: Catastrophic reject(s) removed from data after this point.

TABLE 5
GROUP II TEMP STRESS I DATA SUMMARY

PARAMETERS	$I_R = 15\mu A(\text{MAX})$		$V_F = 1.5V(\text{PK}) (\text{MAX})$			
CONDITIONS AND LIMITS	$V_R = 400V$		$I_F = 38A(\text{PK})$			
IDENTIFICATION	SIE	NOT	SIE	MOT		
INITIAL DATA						
MIN VALUE	1.510 μA	966.0nA	1.260V	1.160V		
MAX VALUE	5.070 μA	3.250 μA	1.480V	1.280V		
MEAN	2.581 μA	1.822 μA	1.353V	1.209V		
STD DEV	949.5nA	617.9nA	63.61mV	35.44mV		
INTERIM DATA (INITIAL TO FINAL)						
Δ MEAN VALUE						
TOTAL HRS						
TEMP (T_A)						
160	4.507 μA	1.248mA	-5.000mV	-1.000mV		
75°C	*622.3 μA	-1.497 μA	7.000mV	18.00mV		
320	-1.953 μA	-1.506 μA	4.000mV	17.00mV		
100°C	.3570 μA	*2.207 μA	4.000mV	41.00mV		
125°C	-.3390 μA	JOB STOPPED	6.000mV	JOB STOPPED		
150°C	.4680 μA	JOB STOPPED	18.00mV	JOB STOPPED		
175°C	3.553 μA	JOB STOPPED	37.00mV	JOB STOPPED		
200°C	JOB STOPPED	JOB STOPPED	JOB STOPPED	JOB STOPPED		
225°C	JOB STOPPED	JOB STOPPED	JOB STOPPED	JOB STOPPED		
250°C	JOB STOPPED	JOB STOPPED	JOB STOPPED	JOB STOPPED		
275°C	JOB STOPPED	JOB STOPPED	JOB STOPPED	JOB STOPPED		
300°C	JOB STOPPED	JOB STOPPED	JOB STOPPED	JOB STOPPED		
FINAL DATA						
FINAL TEMP (T_A)						
225°C	2.280 μA	5.050 μA	1.280V	1.160V		
150°C	10.40 μA	62.30 μA	1.530V	1.380V		
MIN VALUE	6.134 μA	23.89 μA	1.390V	1.250V		
MAX VALUE	2.678 μA	20.55 μA	76.53mV	65.90mV		
MEAN						
STD DEV						

* NOTE: Catastrophic reject(s) removed from data after this point.

TABLE 6

GROUP III TEMP STRESS II DATA SUMMARY

PARAMETERS	$I_R = 15\mu A(\text{MAX})$		$V_F = 1.5V(\text{PK}) (\text{MAX})$			
CONDITIONS AND LIMITS	$V_R = 400V$		$I_F = 38A (\text{PK})$			
IDENTIFICATION	SIE	MOT	SIE	MOT		
INITIAL DATA						
MIN VALUE	982.0nA	18.20nA	1.150V	1.100V		
MAX VALUE	12.60 μA	864.0 μA	1.450V	1.450V		
MEAN	2.602 μA	56.50 μA	1.330V	1.246V		
STD DEV	2.887 μA	208.5 μA	77.78mV	80.62mV		
INTERIM DATA (INITIAL TO FINAL)						
Δ MEAN VALUE						
TOTAL HRS	TEMP (T_A)					
16	150°C					
32	175°C					
48	200°C					
64	225°C					
80	250°C					
96	275°C					
112	300°C					
	107.5 μA	*627.9 μA	16.00mV	13.00mV		
	59.45 μA		27.00mV			
	22.17 μA		34.00mV			
	56.50 μA		32.00mV			
	40.80 μA		106.0mV			
	.2570 μA		131.0mV			
	3.996 μA		100.0mV			
FINAL DATA						
FINAL TEMP (T_A)	300°C	150°C	300°C	150°C		
MIN VALUE	1.050 μA	19.40nA	1.190V	1.180V		
MAX VALUE	44.80 μA	9.990mA	1.580V	1.500V		
MEAN	6.598 μA	684.4 μA	1.430V	1.259V		
STD DEV	11.080 μA	2.413mA	95.15mV	91.76mV		

* NOTE: Catastrophic reject(s) removed from data after this point.



TABLE 7
FINAL DATA SUMMARY

PARAMETER	SPECIFICATIONS LIMIT		U N I T S	MEAN INT. DATA	AVERAGE Δ IN MEAN VALUE					
	MIN	MAX			POWER STRESS		TEMPERATURE STRESS I		TEMPERATURE STRESS II	
					SIE	MOT	SIE	MOT	SIE	MOT
I _R	-	15	μA		*+134.14	*+75.414	*+89.842	+5.0788	+41.525	*+627.90
V _F	-	1.5			+ .02195	+ .03595	+ .01014	+ .01875	+ .06371	+ .01300

* NOTE: Catastrophic reject(s) removed from data after this point.



TABLE 8 STEP STRESS

CATASTROPHIC

FAILURE SUMMARY

JAN TX1N3893

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
100% 50 hr.	0	-	0	-
100 hr.	2	A	1	A
100 hr.	0	-	0	-
250 hr.	0	-	0	-
125% 10 hr.	0	-	0	-
15 hr.	0	-	2	C
25 hr.	1	A	0	-
100 hr.	0	-	0	-
100 hr.	0	-	1	C
250 hr.	2 1	B C	1	C
150% 10 hr.	1	B	0	-
15 hr.	0	-	1	C
25 hr.	0	-	0	-
100 hr.	1	B	0	-
100 hr.	0	-	3	C
250 hr.	0	-	JOB STOPPED	
175% 10 hr.	1	B		
15 hr.	JOB STOPPED			
25 hr.				
100 hr.				
100 hr.				
250 hr.				

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T _A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75°C	0	-	2	A
100°C	1	A	0	-
125°C	0	-	0	-
150°C	0	-	7	C
175°C	2	C	JOB STOPPED	
200°C	2	C		
225°C	7	C		
250°C	JOB STOPPED			
275°C				
300°C				

NOTES: A - $I_R > 1.5\text{mA}$ B - $V_F > 2.25\text{V}$

C - Visual (other than handling)

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T _A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	0	-	8	C
175°C	0	-	JOB STOPPED	
200°C	0	-		
225°C	0	-		
250°C	0	-		
275°C	0	-		
300°C	1	C		

MFR "A" - SIEMENS

MFR "B" - MOTOROLA

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JAN TX1N3893

FAILURE SUMMARY

PARAMETRIC

TABLE 9 STEP STRESS

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	1	A	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
100% 50 hr.	1	A	2	A
100 hr.	7	A	0	-
100 hr.	0	-	0	-
250 hr.	0	-	1	A
125% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	1	A	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
150% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	1	A
100 hr.	0	-	0	-
250 hr.	1	A	JOB STOPPED	
175% 10 hr.	0	-		
15 hr.	JOB STOPPED			
25 hr.				
100 hr.				
100 hr.				
250 hr.				

GROUP II 160 HR. TEMP. STEPS

TEST STEP (T _A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75°C	2	A	0	-
100°C	0	-	0	-
125°C	0	-	1	B
150°C	0	-	3	A
175°C	0	-	JOB STOPPED	
200°C	0	-		
225°C	0	-		
250°C	JOB STOPPED			
275°C				
300°C				

GROUP III 16 HR. TEMP. STEPS

TEST STEP (T _A)	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	7	A	0	-
175°C	0	-	JOB STOPPED	
200°C	0	-		
225°C	0	-		
250°C	1	C		
275°C	1	C		
300°C	0	-		

MFR "A" - SIEMENS

MFR "B" - MOTOROLA

NOTES: A - I_R limit failure

B - S/N 272 removed from testing as MIL-S-19500 failure

C - V_F maximum limit failure

D - S/N 241 removed from testing as MIL-S-19500 failure



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APPENDIX A

FAILURE ANALYSIS

TEMPERATURE STRESS



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FAILURE ANALYSIS

Date 10 November 1978

J/N 2CN242-10B P/N 1N3893 MFR SIEMENS

FAILURE VERIFICATION:Limit:
150A Max.Limit:
1.5V Max.

S/N	PIV -volts-	I_R @ 400 V.dc	V_F @ 38A dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
224	700 *	2 μ A *	Cannot test	13 (200°C 960 Hrs. Tot)	Missing lead
228	600 *	2 μ A *	Cannot test	15 (225°C 1120 Hrs. Tot)	Missing lead
230	600 *	5 μ A *	Cannot test	15 (225°C 1120 Hrs. Tot)	Missing lead
		* Probe test of die after de-lidding.			

INTERNAL VISUAL INSPECTION

All three Siemens devices had lost their anode lug, wire, and tubule. Their die is still attached to the stud, with only the top contact missing (see Figure A-1).

*^hFE trace present. Cannot meet stated test conditions. (Leaky)
**^hFE trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable



JANTX1N3893

FAILURE ANALYSIS

Date 10 November 1978

J/N 2CN242-20B P/N 1N3893 MFR MOTOROLA

FAILURE VERIFICATION:Limit:
15 μ A MAX.Limit:
1.5V MAX.

S/N	PIV -volts-	I_R @ 400 V.dc	V_F @ 38 A dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
274	190 (then neg. R)	Cannot reach 400V	1.0	03 (75°C 160 Hrs. Tot)	I_R
281	500	3 μ A	1.1	09 (150°C 640 Hrs. Tot)	Visual
283	540	2 μ A	1.2	09 (150°C 640 Hrs. Tot)	Visual

INTERNAL VISUAL INSPECTION

S/N 281 and 283 have come apart at the bonding joint between the cup and the stud.

All samples were free of internal visual defects, except for bonding material covering the die on S/N 274 (see Figures A-2 through A-4).

*^hFE trace present. Cannot meet stated test conditions. (Leaky)
**^hFE trace very leaky.

D=drift H=hysteresis Inv=inversion R=resistive S=soft Uns=unstable

**CONCLUSION:**

With the exception of Motorola S/N 274, all the semiconductor elements of these samples were still functional and within the military limits. All device failures were due to heat effects.

The loss of the glass seal tubulation and wire lead on the Siemens devices was caused by the extreme heat of the test temperatures. This problem did not exist on the Motorola samples.

A major weak point for both vendors was the melting of bonding material. On S/N 218 and 283 (Motorola) the cup-to-stud detached, and the devices came apart (see Figure A-2). On S/N 274, the bonding material melted at the internal wire attachment only. This melted metal flowed across the semiconductor die and shorted it out (see Figure A-4).

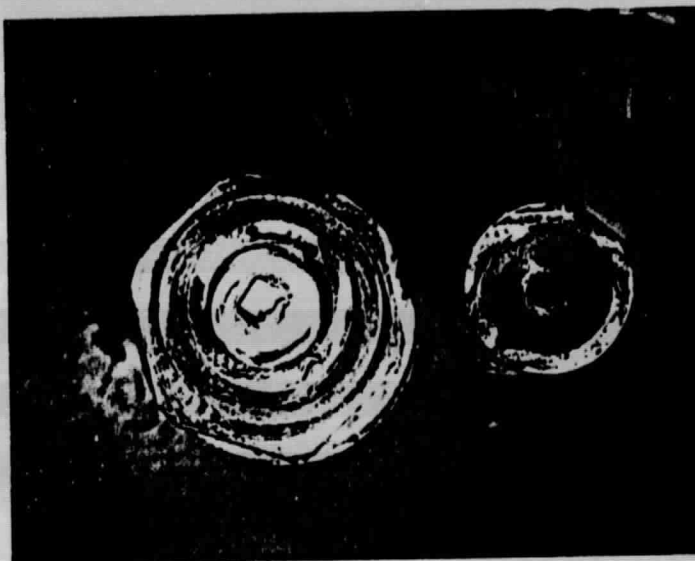


FIGURE A-1
S/N 230, Siemens, 3.3X.
Typical internal view of device showing die
attached to stud, and missing anode wire and tubule.

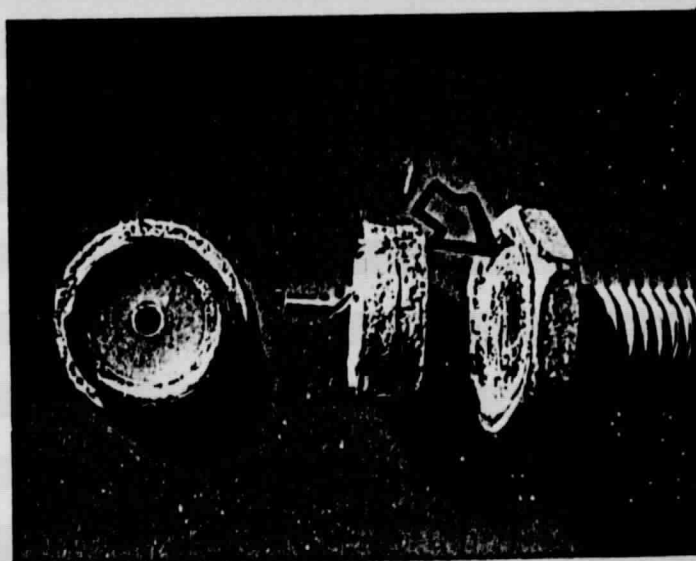


FIGURE A-2
S/N 281, Motorola, 2.6X.
Typical view of diode after de-lidding.
The cup was separated from the
stud when received for analysis (arrow).

ORIGINAL PAGE IS
OF POOR QUALITY



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ORIGINAL PAGE IS
OF POOR QUALITY.



FIGURE A-3
S/N 283, Motorola, 6X.
Silastic junction coating partly removed,
showing undamaged internal die contacts.
Arrow indicates edge of die (compare with Figure A-4).



FIGURE A-4
S/N 274, Motorola, 9X.
Internal view. Arrow points to silicon die completely
submerged and shorted out by metal.
(Compare with Figure A-3.)